

which is one of the items mentioned in the catalogue of the sale of the collection, of which a copy is preserved in the British Museum (Nat. Hist.). William Bullock originally had a museum in Liverpool, but moved his collection to London about 1809, and apparently built the Egyptian Hall for its reception. The collection was sold by auction in London in the spring of 1819, when a number of specimens were purchased for the British Museum by Dr. Leach. Large extracts from the sale-catalogue are given in the second volume of the 'History of the Collections of the British Museum (Nat. Hist.)' The source of the plate, which was not known to the exhibitor, is indicated in the legend to the illustration.

The following papers were read:—

1. Some Living Shells, their recent Biology and the Light they throw on the Latest Physical Changes in the Earth.—I. *Mya arenaria*. By Sir HENRY H. HOWORTH, K.C.I.E., D.C.L., F.R.S., F.Z.S.

[Received June 5, 1909.]

(Text-figures 236–243.)

In his paper on the proofs of a general rising of the land in certain parts of Sweden, published in the 'Philosophical Transactions' for 1835, p. 10, Lyell, in speaking of the living testacea of the Baltic, says:—"In regard to the shells I may observe that the *Mya arenaria* is the *only* one found by me in great abundance in any part of the Baltic which I did not see among the fossils of any of the localities already mentioned or those afterwards to be alluded to further to the North," *i. e.*, in the raised beds. This notable observation, then made for the first time, lay dormant for many years, and it was not until 1872, when engaged in exploring the coast of Skåne, the southern province of Sweden, that Nathorst remarked of an old raised beach situated 8 or 10 feet above the sea-level at Alnarp, near Malmö, in which the littoral shells, then living in the adjoining Sound, were found, that *Mya arenaria*, which is now common there as a living shell, did not occur, and he went on to suggest that it may have been a recent immigrant into the Baltic.

Nathorst's suggestion was presently confirmed in a remarkable manner by C. G. J. Petersen on Danish ground. In Rördam's memoir on the raised beaches of Zealand he in 1892 called attention to the fact that *Mya arenaria*, although such a toothsome mollusc, had never been found in the kitchen-middens of Denmark, nor in the raised beaches of the Isefiord, &c., which synchronize with them, and he concluded very reasonably that

the shell had in fact invaded the Baltic since the kitchen-midden men lived along the fiords of Denmark. Petersen's view is now generally accepted. It is possible, however, and important, to define more definitely the period when the shell first invaded the Baltic. It is first referred to by its recognised name in the tenth edition of the 'Systema Naturæ' of Linnæus, in which, however, he mentions that, in his work on his travels in West Sweden, he had already described it under the name *Concha arenaceo marino*. On turning to this reference, which has not been sufficiently appreciated, I find that he describes the shell at some length among the discoveries he made while at Oerost, an island in the district of Bohuslan, in West Gothland (see 'Wästgöta Resa,' 1747, p. 187). He adds that *he had never found it in any part of Sweden*, and clearly implies that he had not seen it until he went to Oerost. In his description of the discovery of the shell he tells us how, in searching the tide-washed sands at Oerost, he noticed a number of twin holes here and there unaccompanied by the little mounds of sand thrown up by burrowing worms, and, having put the stem of his long tobacco-pipe in some of them, was surprised to find it had struck against something hard. On burrowing with his hands he came upon the mollusc we call *Mya arenaria*, and that occasion was apparently the first time it had been noticed that molluscs in shells as well as freely moving worms dig holes of this kind. He goes on to say that the shell was found always buried under the sand-floors and never thrown upon the beach. This is confirmed by the habitat he gives the shell in his 'Fauna Suecica,' where he says of it: "*Habitat in Oceano Bohuslan alluente.*" As the visit of Linnæus to Oerost was made in 1747, when he was familiar with the zoology of Eastern Sweden, it amounts to a fairly complete proof that the shell was not living in the Baltic in 1747, and that it was only when he explored the coast of the Cattegat that he first found it.

Lyell, in the memoir already cited, and writing in 1835, goes on to say that it did not then live in the Bothnian Gulf as far as Södertelji, that he could not find it even at Calmar, while further south, at Sölvitzborg, it was rare and of very small size (*op. cit.* p. 10).

Kojenikof, writing in 1892, says that all the specimens he had found were young, by which he perhaps means they were dwarfed. He mentions its present distribution in the Baltic thus—Rügen, Stralsund, Greifswald, Stolpe, the Bay of Dantzig, Calmarsund, Gotland, near Memel, Libawa, Windawa, near Riga, Dago, Oesel, Hapsal, Matzalswick, Réval, near Narva, and the Bothnian Gulf as far north as 62°35' N. This proves how widely and rapidly it had spread in the Baltic since its introduction, and how much at home it now is in brackish water.

Long ago Dr. J. E. Gray had already said of the species that it is often found so high up the rivers that the water in which it lives is brackish only during high tides, adding that it is found moreover with freshwater shells on the coasts of the Baltic, while all

the other species of the genus are found only where the water is quite salt (Phil. Trans. 1835, p. 309).

Although it can live where the salinity of the water is comparatively slight, and is found in brackish water in the inlets on our own coast where the marine molluscan fauna is poor, it shares the feature of all marine shells transported to less salty water in being dwarfed and having a thinner shell. Thus in proceeding eastwards in the Baltic, where the water gradually grows fresher, we find its normal length in the Harbour of Kiel to be 100 mm., in the Gulf of Finland 55-70, and in the Bothnian Gulf 36.5.

The fact that so far as is known it does not occur anywhere in the Baltic in a raised beach however slightly elevated, or in a subfossil condition, makes it plain that since its introduction, there has been no appreciable elevation of the coasts of the lands bordering that sea. This may be said with some confidence of the period since Lyell wrote his Bakerian lecture in 1835, *i. e.*, about seventy-five years ago when we know it was living in the Baltic.

We will now turn to the Danish waters. There the evidence is equally plain that the shell we are discussing has only arrived recently. In his memoir entitled "Kartbladet Skamlingsbanke," describing the district on each side of the Little Belt, published by the Geological Survey of Denmark in 1907, A. Jessen has a good deal to say about the shells found in the north-western part of the island of Funen at the entrance of the Belt. Among the shells there found he mentions especially *Mya arenaria* as occurring in two places in what the Scandinavians call *Cardium* deposit, or what we should call estuarine mud. These places are both situated in what was lately the upper part of the Gamborg Fiord, but which has been recently embanked and laid dry. The extreme recency of this deposit is shown by an excavation Jessen made in the soil and by the table he gives of the depths at which the various shells in it occurred. The *Mya* only occurs in the surface layer at from .40 to .75 of a metre in depth, and is not found at any lower horizon in this estuarine deposit. It is plain, therefore, that it has only arrived in the Little Belt quite lately.

The only other part of Denmark in which the shell has been found on dry land is in the extreme north of Jutland, on the shores of the Limfiord and in "Wendsyssel," north of that inlet.

In another Danish Survey memoir also written by Jessen, and dated 1905, describing the eastern part of the Limfiord and some of its islands, he publishes some interesting tables of distribution of the shells found in the most recent beds, which he classes in five series. In two of them, namely the raised oyster-beds, of which he describes 22, and in the lagoon deposits still in progress (Lagunedannelser), of which he describes 8, the *Mya* does not occur at all. Among a series of 20 beds which are found bordering fiords and sounds with a stagnant and sluggish water, one only, situated S.E. of Broust, contained *Mya arenaria*. *This deposit was at the sea-level.* At Vejlen, north of the island of

Giøl, and on the south coast of the island of Oeland, in two instances only out of twenty-nine citations of beds from the broader part of the fiord did the shell occur. *In both cases at the sea-level.* Lastly, at Korsholm, south of Normandshage, an island situated in the mouth of the Limfiord, where it opens into the Cattegat, and subject therefore to considerable wave-action, the *Mya* occurred in a beach now being formed from the sea-level up to 1.3 metre in height. This was the only case out of eleven similar deposits quoted where the *Mya* occurred.

It is plain that in all these four cases the deposit may really have taken place within a few years only, and that it has done so certainly since any alteration in the level of the land has taken place.

Turning from the Limfiord to Wendsyssel, we have a more notable occurrence of the shell and one showing how easy it is in these matters to be misled. This was also originally published by Jessen in 1899, in the first volume of the Records of the Danish Survey, Raekke 3, p. 279. He mentions finding the *Mya arenaria* south-east of Nabstjert, in the south of Wendsyssel, at a distance of 300 metres from the present sea-shore, and at a depth of 0.6 of a metre under the sea-level.

Professor Brögger seems to have attached rather more importance to this discovery as qualifying his views of the quite recent arrival of the shell in these seas than it deserved, for in the later memoir already quoted, and published in 1905, Jessen points out that in comparing the map of this district published by the General Staff in 1883 with other maps dating from 1785-1787, it becomes clear that the coast has greatly altered here by silting, and that in the course of 100 years it has advanced 300 metres at Aalback, north of Nabstjert, while the mouth of the river Jerup, south of Nabstjert, had advanced eastwards 600 metres (Jessen's Memoir on the geological map of Aalborg and Nibe, northern part, p. 158 note). This shows that all the discovery at Nabstjert proves is, that *Mya arenaria* was living on the northern coast of Jutland a century and a quarter ago, for the place where it is now found at 300 metres inland was then in fact on the shore.

The Danish evidence, therefore, is perfectly consistent with that of Sweden in regard to the fact that the *Mya arenaria*, which now so abounds in both areas, is quite a recent addition to their marine Mollusca, and has only lately entered the Baltic, the Cattegat, of which the Limfiord is a mere inlet, and the Belts.

Let us now turn to Norway. *Mya arenaria*, according to Sars, now occurs living on all the Norwegian coasts from the Christianiafiord to the North Cape. It has also been reported from the warmer part of the White Sea. Professor Brögger is strongly of opinion, however, that as in Sweden and Denmark so in Norway, the mollusc is a recent arrival, a conclusion he bases on its absence from the raised beaches. (Brögger, "Om de sen-glaciale og post-glaciale Nivåförändringar," Norges Geol. Unders., N. 31, p. 605.)

Sars, who in 1863 had claimed that it occurs in a raised beach in

the island of Oeland, afterwards in 1867 withdrew the statement, and in the first part of his 'Bidrag til Kundskaben om Norges Arktiske Fauna,' p. 92, he says: "*Derimod er den ikke hos os forefundet fossil i vor glaciële Formation, idet Angivelserne om dens Forekomst her, som mins Fader senere har oplyst, grunde sig paa en Forveksling med den i Form og Størelse meget lignende Lutraria elliptica Lamarck.*"

De Geer overlooked this correction when he cited Sars as an authority for the occurrence of the shell in shell-beds at Trondhjem. Gwyn Jeffreys was similarly misled when he claimed that it occurs in the beds of the "glacial formation" at Christiania 50-200 feet above the sea-level, quoting Sars, 'Norges geologiske Undersøgelse.'

It is true that in a posthumous MS. work of Professor Münster he quotes the shell from a shell-bed at Smedholm, near Brevik, but inasmuch as this bed is only 66 m. above the water-level, it would seem from the observations of Oyen at the neighbouring place called Davo, where the conditions are similar, that at Smedholm the *Mya arenaria* has recently been washed up by the tide and been mixed with shells from the other shell-beds. Brøgger similarly explains the finding of the shell at the level of the sea at Vallø, where again it does not occur in the raised shell-beds, no more than it does in those in the shell-beds at Storeng, Tromø and Arendal (*op. cit.* pp. 606-607); so that it is clear that it does not occur in any of the true raised beaches of the Christianiafiord or the Langesundfiord, or in any place on those fiords where there is any evidence that the land has changed its level since its arrival. On this Brøgger and his colleagues are quite agreed.

There only remains one other place in Norway where *Mya arenaria* has been stated to occur in a raised beach, and to which Professor Brøgger attaches more importance. This is at Kadland, at the south-west point of Norway.

In a notice by H. Rasch of a journey he made thither in 1833, he mentions going from Mandal along the river to Kadland. He found on the western bank of the river, where it rises in a kind of precipice 24 feet high, that the upper 16 feet of this was a coarse sand containing no remains, under which lay a bed of vegetable leaves, etc., matted together, *inter alia* hazel, birch, aspen, etc. This bed was sharply defined above and below; the lowest 5 feet consisted of a bed of "leerblandet" sand, in the upper part of which were a few scattered shells, and in the lower, shells in great numbers, consisting of the ordinary mollusca living on the coast, ex. gr. *Ostrea edulis*, *Venus islandica*, *exoleta* and *litterata*, *Mya arenaria*, *truncata* and *arctica*, *Buccinum reticulatum* and *capillus*, *Turbo littoralis*, *Trochus cinereus*, *Turritella terebra* and *edule*. The river at this point was a rapid one. (Mag. f. Naturvidensk. etc. 1836, pp. 299 & 300.)

Keilhau, who visited the place in 1838, confirmed the description of Rasch, giving more details. He reported further that he had been told that when the tide in the sea was high there was a large indraft of salt-water up this river, so that it became

brackish as high as Kadland. (Nyt Mag. f. Nat. vol. i. (1838) p. 187.)

It is unfortunate that no one has visited and critically described this important section since 1838, for the facts as reported seem very hard to explain. That a peculiarly littoral mollusc like *Mya arenaria* should have lived with a number of others whose habitat was several feet under water seems incredible. It appears to me a great deal more likely that, like other cases before cited, the *Mya* was an adventitious stranger in the shell-bed, and either had come up from the sea with the intruding salt-water as above mentioned and got mixed with shells of an earlier date, or had been able to live at Kadland for a while during some period when the access of salt-water was more continuous. It seems further incredible, from what we know of the habits of the mollusc and its adaptability, that if it had reached the Skawe, in Norway, before the coast had risen several metres at that point, that it should not have occurred in other raised beaches somewhere in Scandinavia, and should not also have found its way into the Christianiafiord and thence into the Baltic until so lately, and I cannot square Brøgger's statement on page 556 that at Kadland the *Mya* may date from the time of the upheaved shell-bed, with his statement on page 605 where he says: "*Også i Norge var Mya arenaria hidtil ikke anført fra postglacial forekomst.*" The only other explanation of this Kadland shell-bed is that it may be of a different age to the other raised beaches of Scandinavia, and may perhaps represent an earlier horizon than is represented by those shell-beds. Hereby hangs an important issue.

Professor Brøgger is very emphatic about the *Mya arenaria* not occurring in any of the raised beds of Norway, perhaps with the single exception of Kadland, and, as we have seen, the same view is generally held in the North in regard to the raised beds of Sweden and Denmark, and, with one notable exception, this seems incontrovertible. That exception has been overlooked by the northern malacologists and geologists. It is that of the famous shell-beds at Uddevalla and Capellbacken. The evidence is very strong, if not conclusive, that it occurs in the Uddevalla beds, although Brøgger does not mention it in his account of them (*op. cit.* pp. 312-322). Hisinger long ago quoted it as found there, together with *M. truncata* (see *Anteckningar i Physik och Geognosie*, 1831, v. p. 83). Gwyn Jeffreys, in his account of the Mollusca of these beds published in the Report of the British Association for 1863, in which he describes all the collections in the then accessible northern Museums and in private hands, and in which he enumerates 83 species, distinctly mentions *Mya arenaria*, which is numbered 20 on his list. Again, in the British Museum, there is a valve of a typical *Mya arenaria* with the critical hinge perfectly preserved which came from the Thuden collection, and is labelled Uddevalla. Lastly, so far back as 1747, Linnæus seems directly to imply that the shell was found in the same place. This evidence

appears to me nearly conclusive, and it would seem to require us either to revise the decision of Brögger and A. S. Jensen that the shell does not occur in the Scandinavian raised beaches at all or to put the Uddevalla shell-beds in a different category to all the other raised beaches in the North, with the possible exception of the Kadland bed, which is a quite possible solution.

In some papers I have lately published in the 'Geological Magazine' on the recent history of the Baltic, I have tried to bring together the conclusions of the Scandinavian geologists on the subject, with some additional views of my own. I will shortly condense their main conclusions. The Northern geologists have shown that the raised beds on the shores of the Baltic consist of two entirely different series, one containing marine shells and the other freshwater and land shells only.

The marine shells in these raised beds correspond to the present marine fauna of the Baltic, except only that they show a change in their range due, as is virtually certain, to the water of the sea having become increasingly fresh. The typical shells in these raised beds are two species of *Littorina*—*Littorina litorea* and *Littorina rudis*, both of them greatly dwarfed. Hence they are known as *Littorina* beds.

The freshwater beds, which immediately preceded them in time, are specially marked by the presence of *Ancylus fluviatilis*, and are hence called *Ancylus* beds.

The inevitable conclusion from the position and succession of these beds is that the Baltic was formerly a great inland freshwater lake (the *Ancylus* sea) and in course of time was converted into a brackish-water sea (the *Littorina* sea), which still subsists although less saline than it once was.

The accepted explanation of this change, a most reasonable and inevitable one, confirmed by much evidence, is that after the human period known as the Kitchen-midden period there was a breach made in the land-bridge connecting Southern Scania with Denmark and Denmark with Mecklenburg, by which the Sound and the two Belts were opened, and the salt water of the North Sea for the first time made its way into the previously fresh *Ancylus* lake, converting it into a brackish-water sea and supplying it with the marine fauna which now occupies it.

The northern archaeologists on very reasonable data have roughly calculated that the Kitchen-midden men lived some 8000 years ago. Whether more or less, it follows that every raised beach in the Baltic containing a marine or brackish-water fauna has been laid down since the above-named breach took place. In other words, the *Littorina* period in the history of the Baltic extends roughly from 8000 years ago down to our own time. This means that during the last 8000 years there have been great changes of level in the Baltic lands involving their upheaval, and the elevation of the highest of these shell-beds is a measure of the amount of this elevation. They show that the movement has not been continuous but differential, the highest recorded instance being at a height

of 330 feet above the sea at Hernösand ('Sounnar Kursernai,' Upsala, 1893, p. 16), whence the highest range gradually sinks northwards to 51 metres at Neder Kalix at the head of the Gulf of Bothnia (De Geer, G. F. i Stock. För. xii. p. 104). From Hernösand the maximum elevation similarly falls gradually as we proceed southward, until in Southern Scania it is not more than 2 or 3 metres. The amount of elevation is similarly differentiated when measured transversely, being highest in the upper country and sinking gradually as we proceed towards the coast on either side. It has been made out further that this movement extends westwards also, and that we can draw isobaric lines along various parallels of latitude, showing that the rise of the Baltic coast of Sweden was paralleled by a corresponding elevation on its western coast, where it is similarly marked by raised shell-beds. These shell-beds on the shores of the Cattegat correspond in time to, but differ generally in contents from, those of the Baltic, just as the Cattegat differs and has always differed from the Baltic in its salinity and consequently in its wealth of marine life.

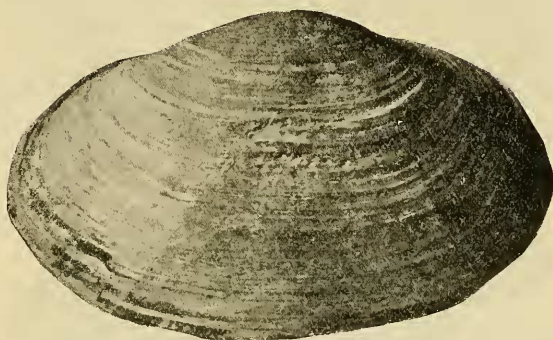
The raised marine shell-beds of Western Sweden have been divided into two sections—one at a much lower level than the other and separated more or less by a blank interval. The contents of the lower beds correspond in the main to the living fauna of the Cattegat, while the upper beds are markedly different.

The famous beds at Uddevalla near Tröllhätten on the River Gotha, already referred to, apparently differ in an important respect from the other beds of similar elevation on the West Coast of Sweden. The peculiarity I refer to was first pointed out by G. Jeffreys, who in 1862 visited Uddevalla and collected 83 species of molluscs there. He showed that in these beds we have a curious collocation of molluscs from deep water with those from shallow water. What is most paradoxical about them, however, is the fact that the deep-sea shells lie over the shallow-water shells. This paradox was reasonably explained by Lyell by the suggestion that, previous to the deposition of the upper shell-stratum, there had been a depression of the ground by which the lower stratum or shallow-water stratum had been greatly depressed, the result being that the deeper-water mollusca invaded an area where the bottom was strewn with a dead fauna composed of shallow-water species. Afterwards both were uplifted together, the deep-water forms necessarily lying above the others, over whose old shells they had travelled when feeding.

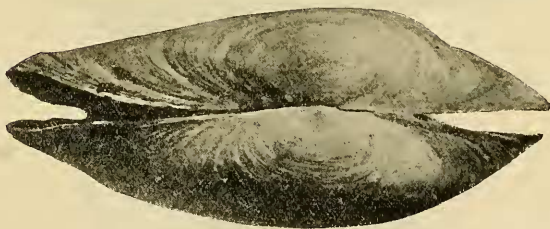
It is a curious confirmation of such a movement having taken place, that in certain parts of the Cattegat two species of molluscs of a type which prevails specially at Uddevalla, each one being consequently qualified as *uddevallensis*, are found in dead and semi-fossilized specimens strewn over the floor of that fiord. These are *Mya truncata* var. *uddevallensis*, and *Saxicava rugosa* var. *uddevallensis*, both having been doubtless killed by the elevation of the sea-bottom which caused their brothers further east to be uplifted 200 feet.

Here then we have a possible explanation of the problem we are seeking to solve, namely the presence of *Mya arenaria* at Uddevalla. It would seem that this very littoral shell belongs to the older and lower bed at Uddevalla, which consists of shallow-water and littoral shells, and that it was possibly exterminated in these northern waters by a sudden subsidence of their feeding-ground, which introduced conditions of much greater depth in the sea-bottom, or by some other similar revolution; and that the bed on which they lie represents a phase of the recent history of the marine fauna of Scandinavia not recorded in the books

Text-fig. 236.



Text-fig. 237.



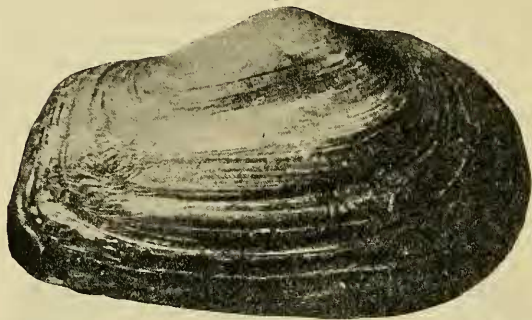
Lateral and dorsal views of shell of *Mya arenaria*; from Prof. W. C. Brögger's 'Om de sen-glaciale og postglaciale Nivåförändringar i Kristianiafeltet,' by kind permission of the author.

and perhaps older than some would credit. It seems to me, in fact, to represent the penultimate stage in the history of the submarine fauna in the Swedish and Norwegian waters, answering probably to the later Crag beds of England. It is possible that the bed at Kadland may represent the same horizon. In this way, and in this way only, can I explain the former presence at Uddevalla of a shell like *Mya arenaria*, which after having been extinct in these waters for at least 8000 years has now invaded them again and has rapidly occupied a much wider area.

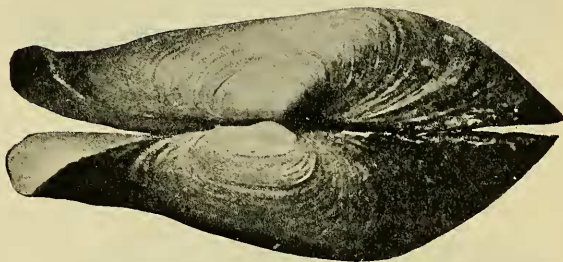
Suppose we accept this view as a tentative one, and proceed a

little further on our way and see how far the conclusion is borne out by other facts in the history of this remarkable shell. The question I would next ask is: Whence did *Mya arenaria* come

Text-fig. 238.

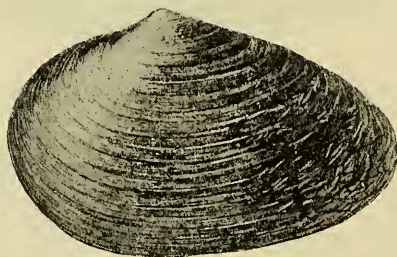


Text-fig. 239.



Lateral and dorsal views of shell of *Mya truncata*; from Prof. W. C. Brögger, *op. cit.*, by kind permission of the author.

Text-fig. 240.



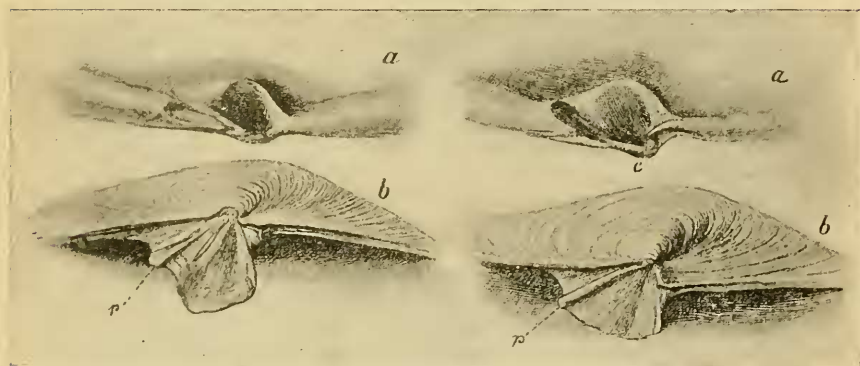
Lateral view of left shell of young *Mya truncata*; from A. S. Jensen, in 'Vidensk. Meddel. naturhist. Foren. i Kjöbenhavn,' 1900, by kind permission of the author.

when it invaded the Scandinavian seas? There are two species of *Mya* inhabiting the Scandinavian seas at present—*M. arenaria*

(text-figs. 236 & 237) and *M. truncata* (text-figs. 238 & 239). They differ very obviously in external contour. The former is an oval shell with its ends curved, one end being more obtuse than

Text-fig. 241.

Text-fig. 242.

Text-fig. 241.—Hinge of *Mya arenaria*.

a, right valve; *b*, left valve; *p*, tip of diagonal keel.

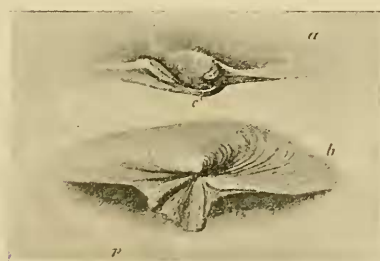
From A. S. Jensen, *op. cit.*, by kind permission of the author.

Text-fig. 242.—Hinge of *Mya truncata*.

c, locking-tooth; other letters as in text-fig. 241.

From A. S. Jensen, *op. cit.*, by kind permission of the author.

Text-fig. 243.

Hinge of *Mya truncata*, var. *ovata*.

Letters as in text-figs. 241 & 242.

From A. S. Jensen, *op. cit.*, by kind permission of the author.

the other, while the other species has one end (that through which the siphon of the mollusc is protruded and answering to the more pointed end of the other species) sharply cut off, whence

its name of *truncata*. This feature is exaggerated in a variety found in the Uddevalla shell-beds and known as *uddevallensis*, in which the shell is cut down to only half its normal size.

This truncation was apparently not a primitive feature of the species, for in young specimens it is hardly marked at all (text-fig. 240), nor is it present in the striations marking the stages of growth of the older shells in their earlier stages. Jensen was the first to point out clearly the important fact that the contours of the two species are really secondary and unimportant features compared with the character of their hinges, which he minutely describes. This can be better seen from the figures annexed (text-figs. 241-243), which he has kindly permitted me to reproduce from his epoch-making paper published in 1900 in the Vidensk. Meddel. naturhist. Foren. i Kjöbenhavn, p. 133.

Testing the specimens of *Myas* which are contained in the Northern Museums by this character of the hinge, he was able to show that all the *Myas* which from their oval outlines had been treated as *M. arenaria*, and which had come from Iceland, Greenland, Spitzbergen, Nova Scotia, the Kara Sea, and Siberia, are shown by their hinges to be really *Mya truncata* and not *M. arenaria*, and he accordingly gave them the name of *M. truncata*, var. *ovata*. This discovery, which has been fully accepted by Brögger and other unimpeachable judges, was very important, since it was on the evidence of these Arctic specimens that *M. arenaria* had been treated as a typically Arctic shell.

Not only so, but the alleged presence of *M. arenaria* in certain shell-beds in Britain had in many memoirs and books devoted to the cultivation of extreme glacial views been treated as a very special touchstone of glacial conditions. All this will now have to be revised as will the labels on many museum specimens. Jensen's emphatic statement, which I will quote in his own words, is conclusive:—"Resulttatet af den forudgaaende Undersøgelse kan i al Korthed udtrykkes saledes at *Mya arenaria* ikke er nogen højnordisk art" (*op. cit.* p. 149).

What is plain, therefore, is that *Mya arenaria* is in no sense an Arctic shell but only a boreal one, and that G. Jeffreys was quite mistaken when he made it so, and when he made the further inference, which has been copied into several geological works and is contained in the following sentence:—"The occurrence of this circumpolar shell-fish so near the tropic of Cancer probably indicates the most southern limit in space of the glacial epoch" ('British Conchology,' iii. pp. 65, 66).

It is further plain that when *Mya arenaria* recently invaded the Scandinavian waters it could not have come from the North. Did it then come from the South-west, from the British seas where it abounds, or from the coasts of Belgium and Northern France, where it occurs as far south as Rochelle? The fact that it does not occur further south in the Bay of Biscay and on the Lusitanian coast is curious. It is not less curious that its very recent history on the British coasts points to its having only

lately spread over the English seas. The first person to write on the English Mollusca in a scientific way was Dr. M. A. Lister, F.R.S., who in his book entitled 'Hist. Anim. Angliæ, etc.,' published in 1678, was the first to mention our shell, which he refers to as "*concha longa lataque*." He gives an excellent figure of the inside of one valve showing the distinctive hinge (plate iv. fig. 19), and tells us it was found in sandy ground near Philo (probably Filey in Yorkshire) and very abundantly at the mouth of the Tees (*op. cit.* pp. 170-171). In the series of plates of English shells dated 1687, entitled 'Hist. Conch.,' and apparently not published till 1770, he figures two varieties of the shell, one more ovate than the other (see nos. 262 and 263), and gives their habitat as "*Mar. Nor.*," by which he meant the North Sea, and it would appear that it was only as a North Sea shell that he knew it.

In his *Hist. Nat. Test. Brit.*, published in 1778, p. 232, Da Costa calls the shell *Chama arenaria*. He says of it: "The species is not common. I have received it from the Isle of Wight, near Newport, and from Hearn Bay, near Faversham, in Kent." This points clearly to the shell being then an uncommon one in the Channel. This is confirmed by the fact that it is not named by Pulteney in the first edition of his 'Catalogue of Birds, Shells, and Rare Plants of Dorsetshire,' published in 1799, but is mentioned and figured in that of 1813 in one of the notes, initialed "T. R." (*i. e.* Rev. Thomas Rackell), p. 28, where he speaks of it as found in Studland Bay, but says it is rare.

It would seem, therefore, that the shell had not been a long time in the Channel when these writers wrote at the end of the 18th century, and that there is a certain probability that it was in fact a newcomer to our seas. This is greatly strengthened when we examine the most recent deposits on our coasts.

It is almost certain that since the Christian era the land has been virtually quiescent in these realms. I know of no evidence to show that it has either risen or sunk during the last 2000 years. The coast has been eaten back in places, estuaries have been silted up and deltas enlarged, and there has been considerable alluvial accretion and growth of shingle-beaches, &c., in others; but in regard to any vertical change up or down, I know of no reliable evidence. All the evidence, on the contrary, points the other way and in favour of the level of the land having been stationary since the Christian era.

The only way, therefore, by which it might be possible to trace any changes in the fauna of the adjoining seas during the interval from the Christian era until to-day, would be an examination of the estuarine deposits and grey loams or buttery clay which have been deposited in such estuaries as the Wash and various inlets such as those on the coasts of Essex, Hampshire, &c., corresponding to the *Cardium* deposit in the now desiccated Gamburg Fiord above referred to. In regard to most of these inlets the available evidence is negative. The geological surveyors report no marine

mollusca from the marine alluvia of those portions of the Essex inlets which have silted up, except an occasional *Scrobicularia*. In their paper on the new dock excavation at Southampton in 1889, Messrs. Shore & Elwes give a list of the marine shells found in the estuarine mud there, which they say are similar to those of the numerous mud harbours on the south coast of Hampshire. The list includes 15 lamellibranchs and 23 gasteropods, but the *Mya* do not occur in it (Proc. Hants. Club, pp. 49, 50).

In the estuarine deposits at Rhyl the only shells found were *Scrobicularia piperata* and *Pholas candida* (see Survey Mem. Rhyl, &c., p. 41).

The evidence is the same from the marsh and fen deposits of Lincolnshire, from which *Scrobicularia piperata*, *Ostræa edulis*, *Cardium edule*, *Tellina solidula*, *Solen siliqua*, *Fusus antiquus*, *Purpura lapillus*, *Littorina litorea*, *Murex erinaceus*, and *Trochus cinerarius* have been forthcoming, but not *Mya arenaria* (see Memoir on the Map of East Lincolnshire, pp. 105–111).

The same is true of the estuary of the Humber, in the alluvium and warp of which we find *Scrobicularia piperata*, *Tellina solidula*, *Cardium edule*, *Littorina litorea*, and *Hydrobia*, but not *Mya arenaria* (Ussher & Reid, Memoir on Sheets 86, 185, and 189). The same is true again of the estuarine deposits in the Firth of Forth. More interesting because much more extensive are the similar Fen deposits round the Wash.

The Wash is clearly the shrunken remnant of what was formerly a great arm of the sea occupying the greater portion of the Fenslands, which has been gradually silting up for a long period by deposition of marine alluvium, and, as Skertchley showed, is in no way a delta deposit. In the now enclosed and desiccated parts of the primitive Wash, Skertchley divides the surface-deposits into what he calls Fen gravels and alluvium. He gives several sections of each, and in his list of the marine shells found in the Fen gravels the *Mya* does not occur. The alluvium he divides into two kinds—namely, clay and warp. In the clay he describes finding *Scrobicularia piperata*, many in single valves, but a fair average with both valves *in situ*; a few shells of *Tellina balthica* and dwarfed specimens of *Cardium edule*, *Mytilus edulis*, and *Ostræa edulis*; occasionally little Rissoas being plentiful. “I have never,” he adds, “found or seen a *Mya* or a *Solen*, although they are common enough in the Wash, neither does the *Cyprina islandica* occur, though it also lives in the Bay” (Survey Memoir on the Fenslands, p. 176).

On a later page, after giving a formal list of the fauna of the inland silts, he continues:—“The silt beds *forming on the shores* contain the same species, but with the addition of *Mya arenaria* and *Mya truncata*, both of which *are common*” (ibid. p. 182). This is surely a very interesting and notable fact, for this warp and marine alluvium of the Fens is the only deposit on a considerable scale in these realms where the latest history of

the English seas can be followed step by step and year by year; and it is a most eloquent fact that while *Mya arenaria* abounds in the present Wash, it does not occur, like the other shells from the same estuary, in the beds deposited in the immediately preceding period, and is very strong evidence of the recent addition of the mollusc to the fauna of the Eastern Coast.

This English evidence may be paralleled by that of Belgium. Thus Dr. Raeymaekers, who describes its common occurrence on the shores of the Low Countries, notably at Ostend, Heyst, and Blankenberg, speaks of it as a recent immigrant. "Malgré toutes nos recherches," he says, "nous n'avons pu découvrir *Mya arenaria* L. dans les dépôts supérieurs à la tourbe. Aucun des géologues qui ont publié des travaux concernant les terrains quaternaires d'Anvers n'a signalé la présence de cette espèce dans les formations modernes; celle-ci ne devait pas encore avoir apparû dans ces parages." He then describes a recent excavation made near Kruyschaus, not far from the redoubt of Oorderen, where he carefully studied all the layers above the turf (tourbe): "Malgré d'actives recherches, nous n'avons pu y trouver des exemplaires de *Mya arenaria* dans la tourbière encore ouverte; au nord au dessus de Doel, nous n'avons pas été plus heureux."

In the turf, he says, there are argillaceous sands, very damp and containing trunks of trees and shells of *Cardium edule*, *Scrobicularia piperata*, and *Tellina baltica*, and then the so-called Polder clay, but no traces of *Mya arenaria*, and he concludes: "Pour notre part, nous croyons que l'époque de l'apparition de *Mya arenaria* L. ainsi que la date de sa disparition du Bas Escaut sont relativement récentes et postérieures à la période espagnole."

Dr. Raeymaekers further showed that the sand covering the ditches at Lille rests on the Polder clay. These ditches he proved were made at the same time as the fortress of Lille, and could be emptied or filled at will by a series of sluices. The sand in question, a thin layer, contains shells of *Mya arenaria* so fresh that their epidermis is still preserved, as is the ligament uniting the valves of the *Cardium edule*. In the war of 1830 the Dutch opened the sluices and the country north of Antwerp was inundated. This continued till 1849-1850, when the Polders were again laid bare and cultivated, and it was during these twenty years that the Myas had invaded the ditches, thus explaining their being now found in dry ground and otherwise so fresh (Annales de la Société Malacologique de Belgique, xxx. pp. 5-11). The evidence, therefore, is very consistent and complete that they have only come to the shores of Belgium in recent times.

If we turn from these estuarine silts, the next deposits we come to are the raised beaches. Raised beaches do not, of course, occur on coasts which are being eaten back by the sea. We do not, therefore, find them on the east coast of England any more than on the western coast of Jutland. They do occur, however, in numerous places on the south and south-west coasts of this island, and afford good evidence that these coasts have not

materially altered in position since they were deposited, for although in the recessed portions of the various bays on the south coast the non-occurrence of raised beaches probably proves that their continuity has been broken at many places, yet their occurrence on the headlands shows that substantially the coastline remains where it was when they were laid down, while the raised beach on the Thatcher Rock in Torbay is another palpable evidence of the same fact.

As I have said above, there is at present no reliable evidence that the relative level of land and water on our shores has altered since the Christian era, and it would seem almost certain that all our true raised beaches—that is, those which represent old beach-surfaces and not mere deposits of pebbles and shells by high tides—are older than Roman times. They may be of different ages, but the persistence of one very notable raised beach at a level of 20 to 40 feet in Scotland seems to point to one particular upheaval having a wider range than could be caused by merely local causes, while the quiescence of the level since the Christian era seems to support the view that the upheaval was rapid and cataclysmic in Britain, as I have tried to show it was in Scandinavia.

The discovery of a number of dug-out boats of a very primitive type in connection with the raised beaches of the Clyde probably points to the relative date of the upheaval as having been in what is called the Neolithic age. A similar inference may perhaps be drawn from the finding of flint tools in connection with the raised beaches in the Isle of Man, in regard to which my friend Mr. Lamplugh writes:—"We gain a valuable clue to the approximate age of this beach in the presence of Neolithic chipped flints on its surface in places. The shingle seems to have been resorted to by the inhabitants for the sake of its pebbles of flint derived from the drift, which have sometimes been struck into flakes on the spot. . . . I found in the outer part of the beach a single artificial flake which had been partially worn down by marine attrition, and must therefore have been in existence as a flake during the accumulation of this portion of the beach. Between Rue Point and Blue Point I found these chips, in one place, in the blown sand covering the inner part of the old shore. These facts denote that at any rate part of the platform was in existence in Neolithic times, but that it may not have attained its full breadth until after the close of that period" (Survey Mem. Isle of Man, p. 403).

Let us now turn to the mollusca of the raised beaches. A monograph on the raised beaches of the southern coast was published by Prestwich in the Q. J. Geol. Soc. xlviii. p. 263. In this paper he gives several lists of shells found in them. In one case only does *Mya arenaria* occur, although the shell is such a common living shell in the Channel, namely on the Thatcher Rock in Torbay, which has a peculiar history and is probably much older than the other raised beaches of the Channel: Pengelly

thought it "pre-glacial"*. It is surely singular that *Mya arenaria* should be absent from all these raised beaches in England save one, as it is from all the raised beaches of Scandinavia save one also, or perhaps two.

Let us now turn to another group of raised beaches and kitchen-middens, namely those in the south-west of Scotland. In his account of the kitchen-midden on the coast of Ayrshire known as the Ardrossan shell-mound, Mr. John Smith tells us that among the shells found in it the genus *Mya* was entirely absent. It is singular notwithstanding this that the most abundant living species at the present day in this district is *Mya arenaria*. In the lower estuary of the Gare Loch it was very abundant in muddy or gravelly sand twenty years ago, but has been almost exterminated for food by the people. (Trans. Geol. Soc. Glas. ix. p. 357.)

In the same writer's account of the whale-bed in Ayrshire he does not mention *Mya arenaria* as occurring either in the so-called glacial beds at Stevenston, Kilwinning, and Troon, or in the raised-beach beds at Shewalton Moor, while he says it is frequent on the present beach from Stevenston to Troon (*ibid.* x. p. 42). It is remarkable, he adds, that *Mya* has not turned up in the raised-beach beds, although one of the species (i. e. *truncata*) is common in the glacial beds and the other (i. e. *arenaria*) is frequent in the estuary of Gare Loch (*ibid.* p. 46).

The so-called Carse clays of the valley in which Stirling and Falkirk lie (which prolong the Firth of Forth westwards) and in which the skeletons of several whales have occurred, are probably of the same age as the lower raised beaches and kitchen-middens of the West Coast. Shell deposits occur in several places in these Carse beds. Thus, that at Cockmalane yielded *Tellina balthica* (var. *solidula*), *Mytilus edulis*, *Cardium edule*, *C. nodosum* (?) young specimen? *Buccinum undatum*, *Littorina litorea*, of large size, *L. rudis*, *Nucula nucleus*, *Trophon truncata*. Elsewhere oyster-beds occur, and also *Tapes pullastra*, *Macra subtruncata*, *Cardium echinatum*, *Trochus cinerarius*, *Purpura lapillus*, *Scrobicularia piperata*, *Rissoa ulvae*, and *Fusus antiquus*. ("The old estuarine beds of the Carse of Stirling," Haswell, Trans. Edin. Geol. Soc. xi. p. 58.) Here it will be seen there is no mention whatever of *Mya arenaria*.

These facts make it almost certain that in the British seas, as in Scandinavia, *Mya arenaria* is quite a recent addition to the marine fauna. The fact that the shell has only quite recently been reported from the Italian seas points to its having also wandered very recently into the Mediterranean. These facts could not well have been known to Professor Brögger, who nevertheless, in trying to find the home from which the shell went to Scandinavia, suggests that it had come not from Britain, but from the Atlantic

* On its occurrence on the Thatcher Rock, see Hunt, Trans. Devon Assoc. 1888' vol. xx. p. 227. The shells in the raised beach here were determined by G. Jeffreys' D. Pidgeon, and J. J. Marshall; among them is *Mya arenaria*.

coast of America, where it occurs as far south as Carolina and northwards to Labrador. Brögger classes it in fact with those other shells in the Christianiafiord which are also recent immigrants and have been very probably derived from America, e. g. *Acmea testudinalis*, *Lophyrus albus*, *Scalaria groenlandica*, *Cerithiopsis costulata*, and *Nucula delphinodonta* (Brögger, *op. cit.* p. 595 &c. and p. 712).

The history of *Mya arenaria* in America is a curious one. Its old home there is on the Atlantic coast of Canada and the United States, where it is a favourite edible mollusc, known as the Clam, but it has quite recently (about 1874) been transported to California to be fattened and has since spread rapidly in San Francisco Bay (see Stearns, *Mya arenaria* in San Francisco Bay, American Naturalist, xv. p. 362).

Let us, however, return to Europe, for we have not yet exhausted the interest of this shell.

While it seems plain that *Mya arenaria* is not found in any of the deposits in Europe later than the drift except in the currently deposited alluvium, there can be no doubt that it occurs, and occurs abundantly, in the Crag beds both in the Red or Suffolk Crag and in the Upper or Norwich Crag and its several divisions. It is quoted by Whitaker from the Red Crag at Beaumont (Mem. on Sheets 48 S.E. and 48 N.E. p. 30). It is also named from the Crag at Bulchamp Pit, Dunwich Cliff, and Southwold (Geology of Southwold, p. 83), from the so-called Chillesden Beds at East Barent by Prestwich (Q. J. Geol. Soc. xxvii. p. 345), and from the so-called Weybourne Crag at Trimmingham, Sidestrand, Overstrand, Runton, Sheringham, and Weybourne, and generally as very common by Mr. Clement Reid; and locally from the Norwich Crag at Burgh near Aylsham by Mr. Harmer, who in another place reports the shell as common in the Norwich Crag (Proc. Geol. Assoc., later Tert. hist. of East Anglia, p. 466).

It is also reported from the shell-bed on the shore at Selsea (see R. Bell, Yorks. Phil. Soc. 1892). This bed is clearly older than the drift, that is to say, is what is generally called pre-glacial, since it underlies the famous gravel-bed which contains very large boulders. G. Jeffreys also quotes it from the Crag of Belgium.

In regard to the Chillesford beds there are some fine, perfect and very typical examples of the true *Mya arenaria* in the British Museum.

It is perfectly plain, therefore, that *Mya arenaria* was living in the British Seas in the period of the Red and Norwich Crag, as it is plain that it is an abundant shell on our coasts now, but that between these two periods it became extinct here and was reimported. This involves some interesting issues. The only marine beds lying between the Norwich Crag and the raised beaches are the drift or so-called glacial beds. What is the testimony of these beds on the question, and what is the exact meaning of that testimony? A very great change has come over geological opinion in regard to the fossil contents of the drift beds during the last thirty years. It was Searles Wood who first separated the so-called Middle Sands of Norfolk from the Crag.

Before him, these sands were treated as true Crag. The difficulty of separating them is in fact very considerable, and it must be allowed that the separation was made on most unsatisfactory grounds, and Mr. Whitaker quite admits in a letter to myself that much which was once thought to be drift has been shown to be Crag.

When Wood and Harmer separated the so-called Middle Sands of East Anglia from the Norwich Crag and its several subordinate divisions, the Weymouth Crag, Chillesford Crag, etc., they proceeded to constitute them a new biological horizon and to treat their molluscan contents as glacial shells. This view Wood subsequently somewhat modified. It was Mr. Horace Woodward who first threw a flood of light on the subject by his suggestion that the shell-fragments, &c., of the drift beds of Eastern England were in no sense at home there, and did not constitute a special biological horizon, but were in every case derivative. In his various papers and memoirs on the East Anglian drifts he has emphasized the point, and I have been indebted to him for much information on the subject.

In his paper on the Glacial Drifts of Norfolk he calls attention to the fact that the fragments of shells found in them represent more than a hundred species identified by Messrs. Wood and Harmer as Crag shells, a considerable number of them belonging to the Coralline Crag. It was this discovery, which seemed to point to warmer conditions, that first started the notion of warm inter-glacial periods interposed in the so-called glacial age. Mr. Woodward entirely disputed the cogency of this evidence. He said: "The aspect of the shells alone makes one sceptical, and it is admitted that they did not live on the spots where they have been accumulated." These beds, he says, "pass southward into gravels which underlie the chalky boulder-clay"; and he urges that the fragmentary shells in them have been largely derived from old Crag formations which were entirely destroyed or buried beneath the waters of the North Sea. Mr. Clement Reid, who once held a different opinion, wrote to me many years ago saying: "The fauna of the Middle Glacial sands of Norfolk, I now have no doubt, is entirely derivative," and proceeded to show very clearly that Searles Wood's theory about their contemporaneity would not hold water. See the whole subject discussed at greater length in my 'Glacial Nightmare,' p. 430; 'Ice and Water,' ii. pp. 104-106 and p. 206. If derivative, I cannot for a moment doubt that they were derived, as Gunn and the earlier Norfolk geologists urged, from the Crag beds, being merely redeposited Crag shells. Wood himself was constrained to admit that they were derived, but argued that they came from some other otherwise unknown glacial beds.

What is true of the East Anglian drifts is almost certainly true also of the drift of Lincolnshire, the shells in which are very fragmentary and rubbed: see Survey Memoir on East Lincolnshire, p. 91, for a long list and description of them; see also the

Memoir on Sheet 86, and pp. 177-183, where the mollusca in several pits are described, apparently in all cases very fragmentary and much broken, and in no case *in situ*.

The drift beds of East Yorkshire tell the same story. Mr. Lamplugh has conclusively shown that none of the shells in the shell-bed at Bridlington nor those found at Dinlington near Spurn Point had been obtained from beds "in place," but from "*masses of sand and clay occurring as boulders in the basement boulder-clay.*" That is, that the shells were transported. Dr. G. Jeffreys at the reading of the paper said he believed from personal inspection that this was a remanié deposit (Q. J. Geol. Soc. xl. p. 326). In his 'Geology of Holderness' Mr. Clement Reid fully admitted the fragmentary and transported character of the shell-beds, and Mr. Lamplugh again remarks on the inclusion in the so-called basement clay of stratified patches of transported sand containing shells. It is clear, therefore, that the Mollusca in the Yorkshire drifts, like those in the East Anglian ones, are derivative and so could only have been derived from the later Crag beds.

Again, Mr. E. T. Newton has expressed the opinion that the whole of the fish-remains at Bridlington are either Norwich Crag, Red Crag, or London Clay; and seeing that so many of the Crag Vertebrata have been originally derived from the London Clay, it is quite possible that all the Bridlington fishes have been derived directly from the Crag. He adds the very important sentence: "I should doubt if any of them were contemporaneous with the Bridlington deposits, and the mineral condition and polished surface of the specimens are characteristic of Crag fossils. This would seem to point to the destruction of older Tertiary beds during the formation of the gravelly sand containing the Arctic fauna." (Q. J. Geol. Soc. xl. p. 322.) Mr. C. Lewis says that the character of the shells in the Weybourne Crag accords well with that of the shells at Speeton.

Travelling further north, we find similar broken and much comminuted shells in the drift beds of Durham and Berwickshire whose condition similarly proves their derivative character. Further north again we find that in the drift beds of Eastern Scotland the shells are precisely in the same condition, comminuted, striated and smoothed, and very seldom whole. Professor Geikie describes them as scattered confusedly through the mass, like the boulders with which they are associated. This is especially the case with the shelly drift covering a large part of Caithness. Moreover, Peach and Horne found numbers of smoothed and striated shell-fragments in the Orkneys. This all points unmistakably to the shells in question being derivative and not *in situ* in the drift beds, and belonging in fact to an earlier horizon. I presume that most people who have seen them as they are found would in fact claim that they are older than the drifts in which they occur, or, to use the language of the glacialists, that they are pre-glacial. According to my view, the marine horizon

immediately preceding the drift was that of the so-called Norwich Crag. I hold, in fact, as I said previously, that there is no such thing as a biological horizon represented by the drift beds of Eastern England and Scotland; that, whether distributed by ice or water, all their biological contents are older than themselves and remanié. This is important in respect of the subject matter of the present paper, since Mr. Lamplugh mentions that *Mya arenaria* has been found in the lower Bridlington beds, although he has not verified the discovery himself.

In one instance I find *Mya* with a query cited from the drifts of Lincolnshire (see Survey Memoirs, Linc. p. 182). *Mya arenaria* has been repeatedly reported as discovered in the drift beds of Eastern England. Wood mentions it in 'The Crag Mollusca.' It is named from Corton by Mr. Harmer in his memoir on the country round Norwich, and by Mr. Blake from Gorleston Cliff in his account of the country round Yarmouth and Lowestoft. The comminuted and water-worn condition of the fragments (whole shells being very rare) makes it often uncertain about the identification of the species of *Mya*, since, as we have seen, it is only the hinge that is of importance. Mr. Blake, speaking of Gorleston, says: "Some of the loamy bands contained finely comminuted shell-fragments, whereas in other places fragments from an inch to more than two inches in length of such shells as *Cyprina islandica* and *Mya arenaria* were seen mixed with smaller fragments, all water-worn" (*op. cit.* p. 39). It is clear that in view of Dr. Jensen's discovery these fragments of *M. arenaria* should be re-examined. What is plain, however, is that, whether they be true *M. arenaria* or not, they have come from re-arranged Crag deposits and have nothing to tell us of any horizon subsequent to the Crag.

Let us now turn to the Irish Sea. It has always seemed to me strange that the writers on the Crag beds should have so entirely limited their investigations to the two sides of the southern part of the North Sea. For it is quite clear that Britain in the time of the Crag was washed by seas on the west as well as on the east as it is now. It startled some people greatly when Jamieson discovered true Crag deposits in Aberdeenshire as late as 1862, and when similar deposits were discovered at St. Erth in Cornwall. Now that we know that the fragmentary shells in the drift of Eastern England are all derived from Crag beds, the problem has become more interesting and important.

It is at least *a priori* probable that what is true of the fragmentary shells in the drifts of Eastern England and Scotland is true also of the broken shells of the drifts of Western England and Scotland, and it has been generally urged that these broken and rubbed shell-fragments are also derivative. Those who know them best are all of this opinion. In my 'Ice and Water' I have quoted Forbes, Meilard Read, Darbishire, Kendall, Crosskey, G. Jeffreys, and the British Association Committee on the beds of Kintyre, for the drifts of Macclesfield, Lancashire, the Isle of Man, Arran, and Kintyre (*op. cit.* ii. pp. 113-119). They are all

agreed on the subject that these fragmentary shells are transported, re-arranged and derived from earlier beds. Now the beds preceding the drift in Western England, just as in Eastern England, must have been deposited in the Crag sea. The shells are no doubt not precisely the same on both sides of England, but the conditions were not quite the same either. It is exceedingly probable that Ireland and Scotland were united at some point during the Crag time, so that the shells in the southern part of the Irish Sea and those in the northern part would have been somewhat different, there being no access in the south to the northern indraft of cold water. This would not affect the contemporaneity of the shell-beds, however, on either side of the island any more than the present divergent fauna of the Baltic and the Cattegat do so.

While the contents of the *drift beds* show every sign of being derivative, this does not mean that all the later beds in the western parts of Great Britain are so. Just as there is every reason for thinking the shell-beds in Nairnshire to be *in situ* and to be, as I have urged elsewhere, older than the drift which overlies them (see *op. cit.* ii. p. 118), so also is it the case with the low-lying shell-beds in the Kyles of Bute and some other sites in Western Scotland. Mr. James Smith, of Jordan Hill, was the first to discriminate two sets of shell-beds in this district (see Smith, 'Newer Pliocene Geology,' p. 79). These seem certainly *in situ* and to be older also than the drift, and in my opinion they represent the later Crag of the West Sea just as the beds at Aberdeen represent the Crag of the North Sea.

Here again our shell *Mya arenaria* comes to our assistance. Just as it abounds in the Norwich Crag so does it abound also in the Bute beds.

Two splendid valves of typical *Mya arenaria* from the shell-beds of the Kyles of Bute are in the British Museum from the Richmond Collection, and are labelled Glacial (see number 35020).

Crosskey and Robertson found the shell in the same place. They in fact presented some specimens of it from the Kyles of Bute to Professor Sars in 1866. Brögger describes them as of the typical form and they still preserve their original label, *Mya arenaria, glacial clays, Kyles of Bute*. To which Sars added in his own handwriting, "glacial" with a query. The shell is named from the same locality in the appendix to Sir A. Geikie's Memoir on the Glacial Drift of Scotland (Trans. Geol. Soc. Glas. i. pt. 2, p. 176).

Robertson and Crosskey also name a single valve of *Mya arenaria* as having been found in the Lochgilp beds (*ibid.* iii. p. 122). These several beds I deem to be what are generally called pre-glacial or, as I prefer to call them, late Crag; and it was from similar late Crag beds that the fragmentary shells in the Isle of Man and the Lancashire drifts were derived and among them the *Mya arenaria*, which is mentioned from the Isle of Man beds at Glen Wyllin by Mr. Kendall.

